| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# GCE A level

1214/01

## GEOLOGY – GL4
### Interpreting The Geological Record

A.M. MONDAY, 2 June 2014

2 hours

| | For Examiner's use only | | |
|---|---|---|---|
| | Question | Maximum Mark | Mark Awarded |
| Section A | 1. | 15 | |
| | 2. | 15 | |
| | 3. | 15 | |
| | 4. | 15 | |
| Section B | 5. | 14 | |
| | 6. | 10 | |
| | 7. | 4 | |
| | 8. | 12 | |
| | Total | 100 | |

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**ADDITIONAL MATERIALS**

In addition to this examination paper, you will need:
- the Geological Map Extract (Whitehaven);
- a hand-lens or magnifier to study the map (optional);
- a calculator;
- a protractor.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question.

Candidates are reminded that marking will take into account the quality of communication used in their answers.

Examiner only

## SECTION A

*Answer* **all** *questions in the spaces provided.*

*This section should take approximately 1 hour to complete.*

**1.** **Figure 1a** shows the external morphology of a fossil (productid) brachiopod in life orientation. **Figure 1b** is a reconstruction showing the muscle system of a similar specimen.

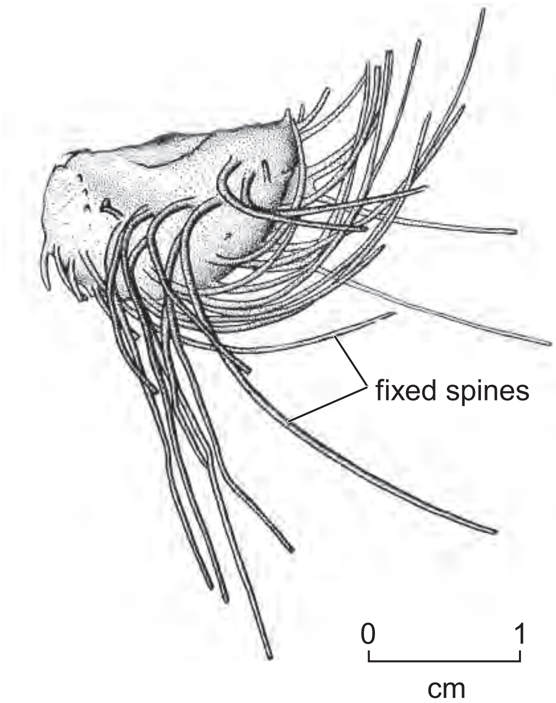


**Figure 1a**

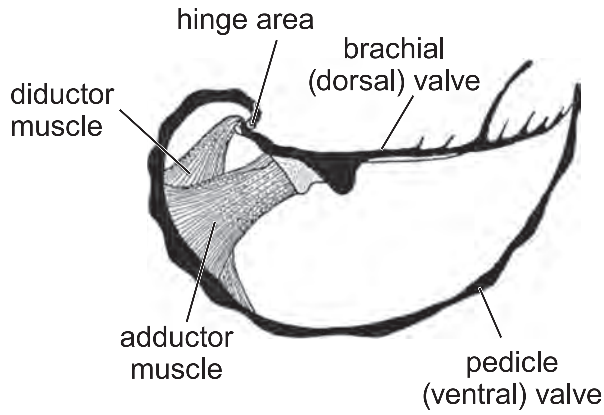


**Figure 1b**

*(a)* Refer to **Figures 1a** and **1b**.

(i) Explain how the productid brachiopod opened and closed its valves. [2]

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(ii) With reference to its morphology, describe the probable mode of life of the productid brachiopod. [2]

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(b) **Figure 1c** is a sketch of a vertical exposure of reef limestone showing true dip.

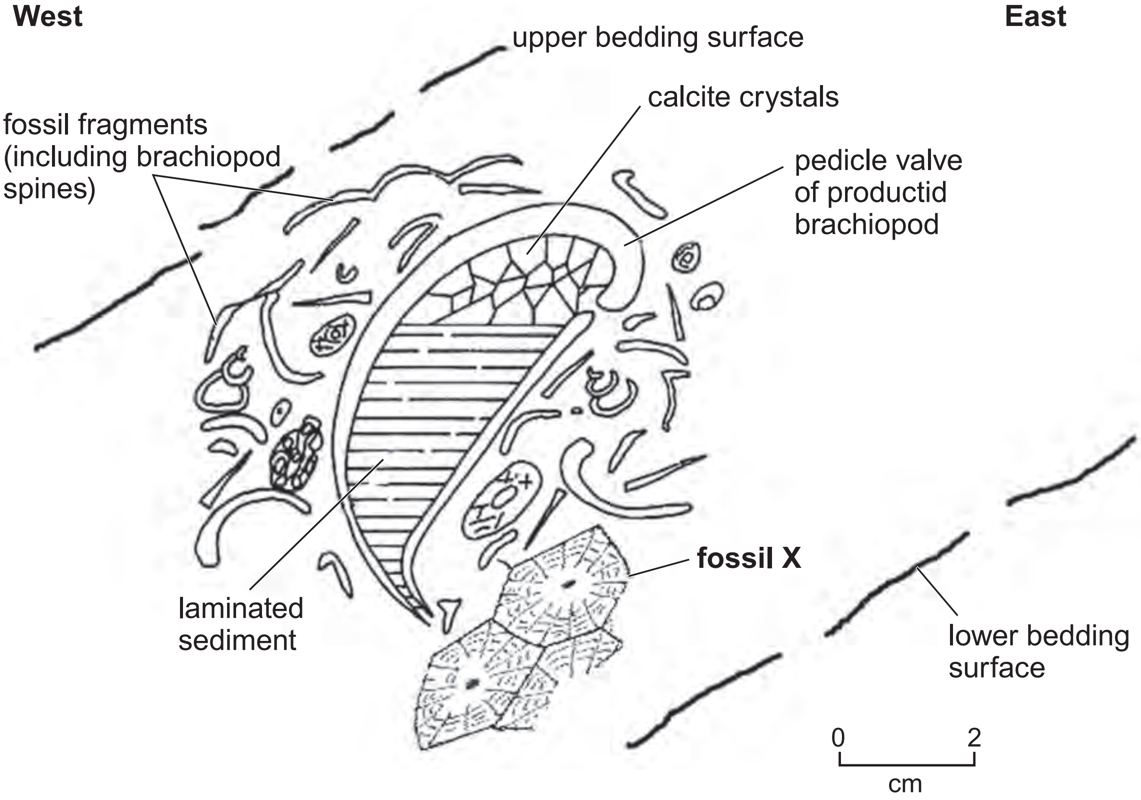


**Figure 1c**

(i) State the fossil group to which **fossil X** in **Figure 1c** belongs. [1]

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(ii) Complete the chart below by measuring the dip of the limestone in **Figure 1c**. [1]

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|---|---|
| Dip angle of the limestone in **Figure 1c** | • |
| Dip angle of the sediment infilling the brachiopod shell | Horizontal - zero degrees |

(iii) Explain how the data in **Figure 1c** support the hypothesis that the limestone was laid down on a **slope** in a high energy, coral reef environment. [3]

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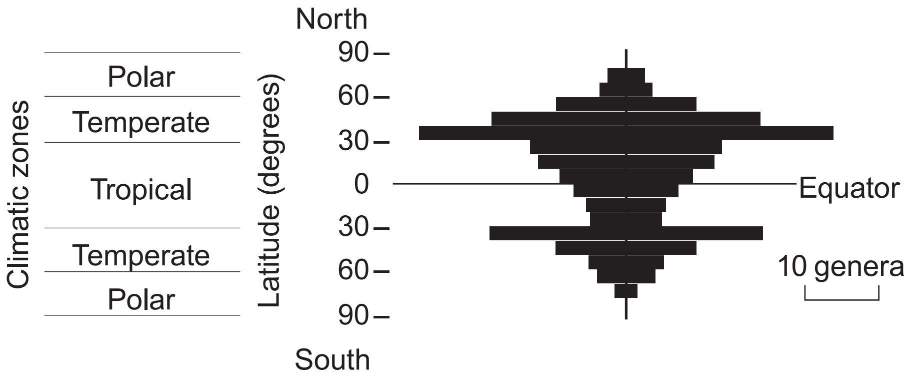
*(c)* **Figure 1d** shows the worldwide distribution of living brachiopods.




The distribution of living brachiopods may be related to
- water depth
- water salinity
- water temperature
- the type of the sea floor (hard rock or mud)

**Figure 1d**

(i) Describe the distribution of living brachiopods in **Figure 1d.** [2]

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(ii) Suggest which **one** of the factors listed in **Figure 1d** is likely to have the most influence on the worldwide distribution of living brachiopods. Explain your answer. [2]

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*(d)* Suggest in which climatic zone (**Figure 1d**) the limestone in **Figure 1c** was probably deposited. Explain your reasoning. [2]

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**2.** **Figure 2a** is a phase diagram showing the experimental crystallisation of plagioclase feldspar over a range of compositions, from Ca-rich plagioclase to Ca-deficient plagioclase, measured in percentage Anorthite (% An).

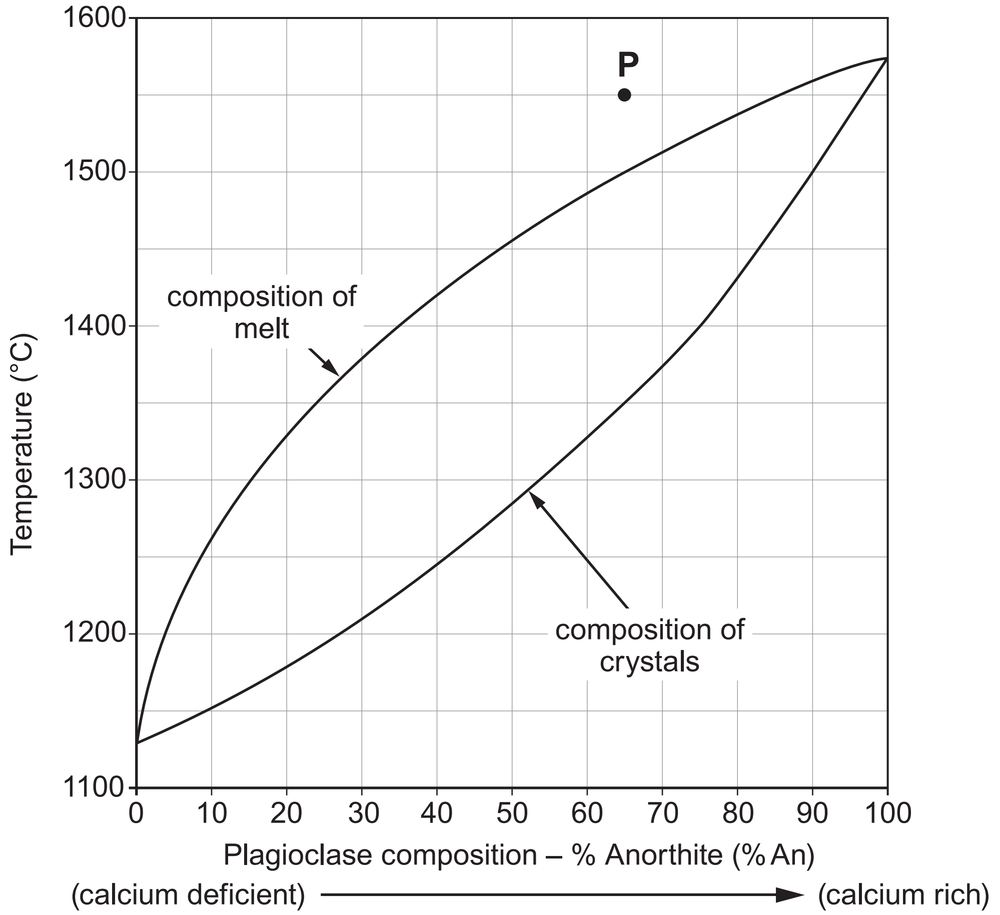


**Figure 2a**

*(a)* Melt **P** on **Figure 2a** has the composition of 65 % Anorthite ($An_{65}$).

Complete the box below to show the crystallisation characteristics of melt **P** as it cools, assuming that the melt remains in **equilibrium** with the crystals that form. [5]

| Melt **P**<br>65% Anorthite | Temperature of melt (°C) | Composition of melt (% An) | Composition of crystals (% An) |
|---|---|---|---|
| Initial crystallisation | • | 65 | • |
| Crystallisation at 1400° C | 1400 | • | 75 |
| Final crystallisation | • | | • |

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*(b)* **Figure 2b** shows changes in the composition of plagioclase feldspar through the Skaergaard Intrusion (Greenland), considered to be a magma chamber which was emplaced by the intrusion of **mafic** magma (**Figure 2c**).

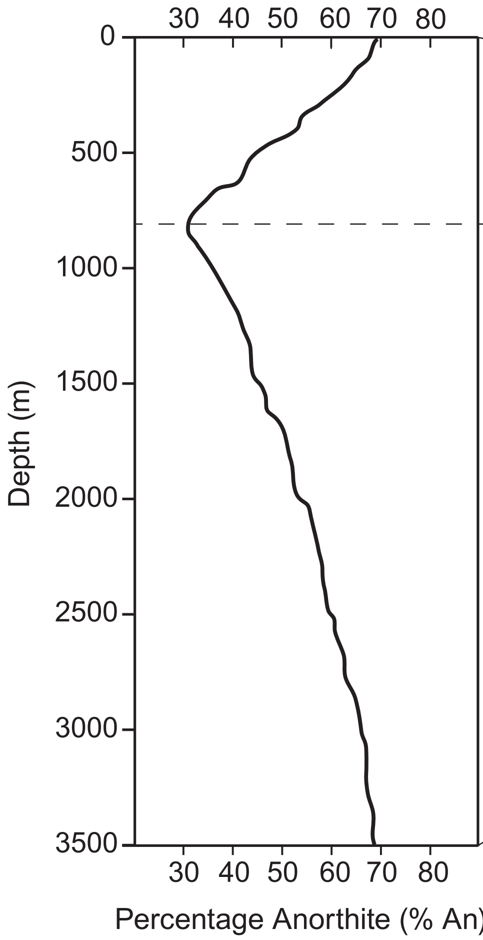
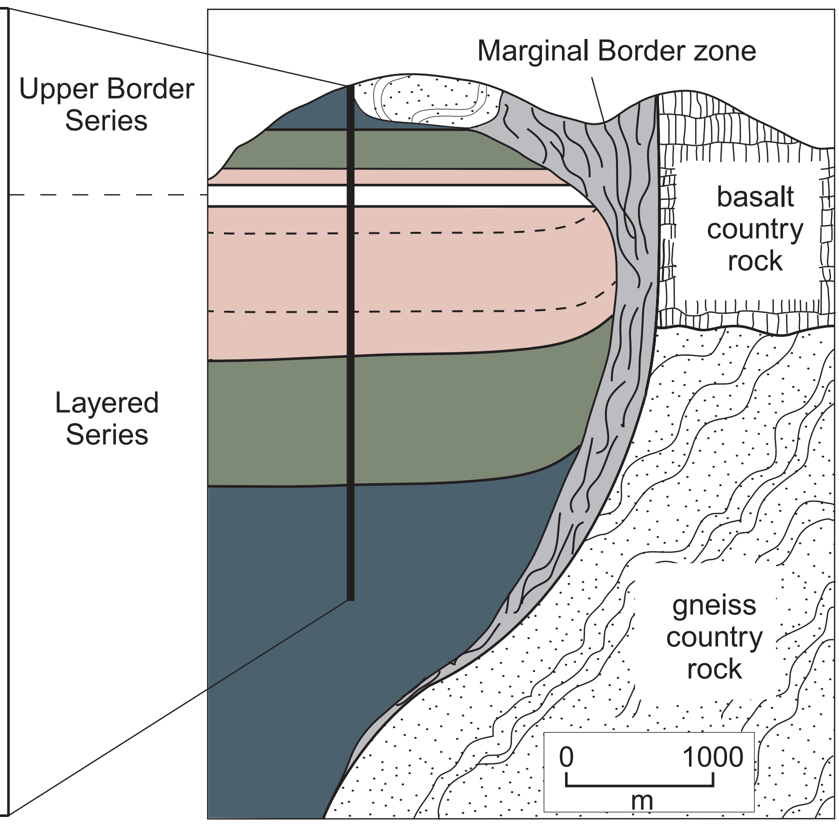



**Figure 2b**




The shading represents zones within the intrusion

**Figure 2c**

(i) Describe the change in plagioclase feldspar composition through the measured height of the intrusion. [2]

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(ii) With reference to **Figure 2a**, account for the variation in plagioclase feldspar composition through the intrusion. [3]

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(iii) The original composition of the magma in the Marginal Border zone has been contaminated by xenoliths from the adjacent country rock. Suggest which of the country rocks is most likely to have caused the greatest change in the composition of the magma. Explain your answer. [2]

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*(c)* **Figure 2d** is a photograph of part the Layered Series of the Skaergaard Intrusion showing the relative density (RD) of minerals within the layers.

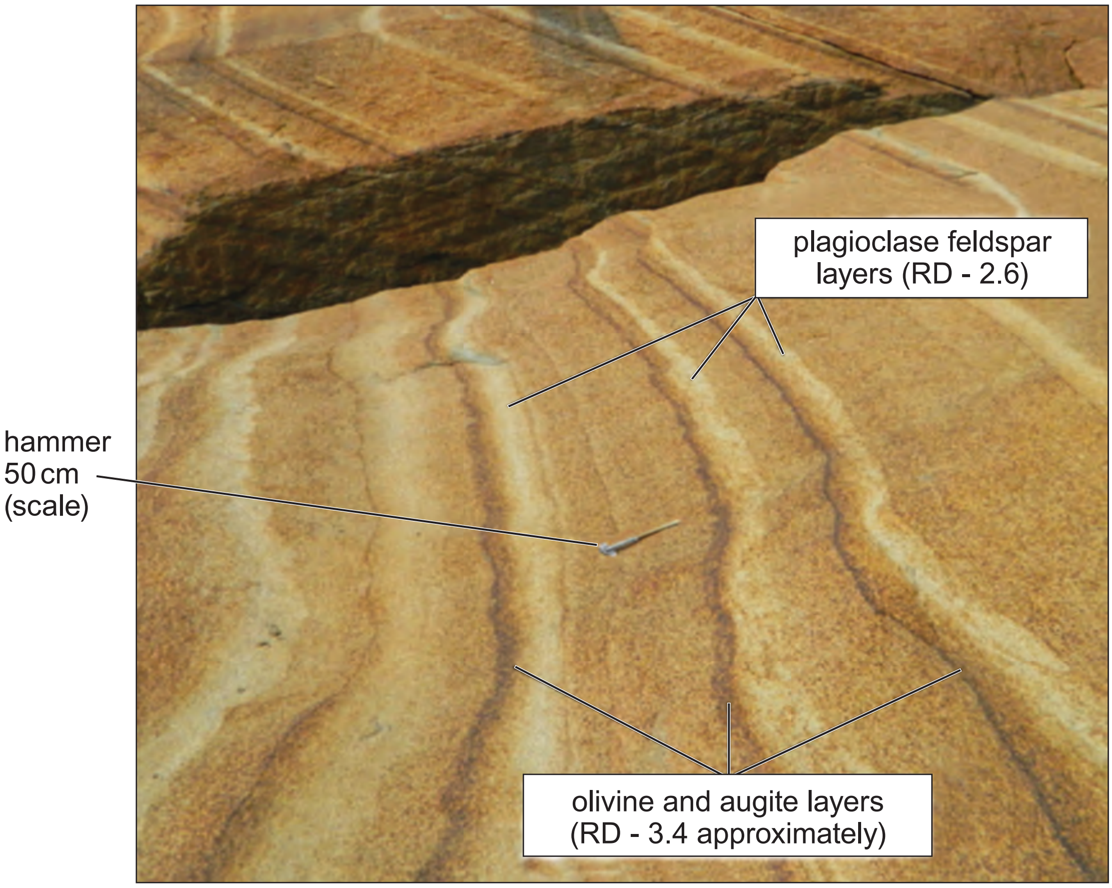


**Figure 2d**

With reference to **Figures 2c** and **2d**, account for the mineral layering. [3]

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Examiner only

**3.** **Figure 3** is a partly drawn coastal cliff section, part of which has been obscured by a landslip.

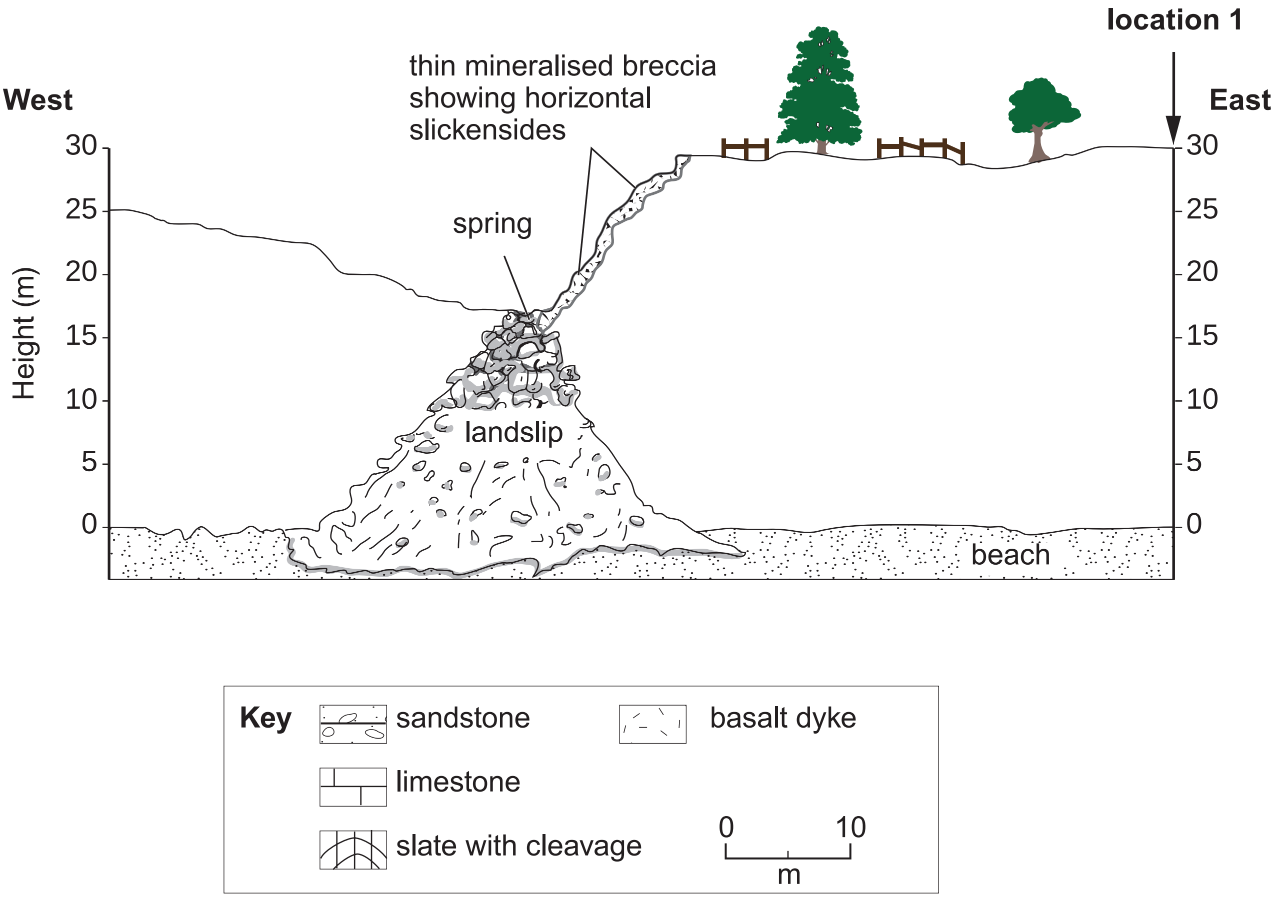


**Figure 3**

<table>
<tr><td>Location</td><td>West of landslip</td><td rowspan="7">LANDSLIP</td><td colspan="2">East of landslip</td></tr>
<tr><td rowspan="6">Geology</td><td rowspan="3">A series of folded slates with an axial planar cleavage dipping 80°E</td><td colspan="2">A vertical section (showing vertical thicknesses) measured at location 1 on the eastern edge of the cliff section (in stratigraphic order – oldest at the base)</td></tr>
<tr><td rowspan="5">Youngest ↑ Oldest</td><td>5 m bedded sandstone, dipping 10° N</td></tr>
<tr><td>Irregular unconformity, dipping 10° N</td></tr>
<tr><td rowspan="3">Cut by a 2 metre thick vertical, basaltic dyke (10 m from the western margin)</td><td>10 m well-bedded limestone, dipping 15° W</td></tr>
<tr><td>Unconformable junction, dipping 15° W</td></tr>
<tr><td>15 m folded slates with an axial planar cleavage, dipping 80° E</td></tr>
</table>

**Table 3**

Examiner only

*(a)* Complete **Figure 3** by sketching in the geological features described in **Table 3**. Use the appropriate shading provided in the key. [8]

*(b)* A student concluded that the difference in geology to the east and west of the landslip could best be explained by:

- a fault, dipping west
- showing normal movement
- that had been reactivated

Evaluate these statements explaining the **evidence** for your conclusions.

(i) *a fault, dipping west* [2]

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(ii) *showing normal movement* [3]

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(iii) *that had been reactivated* [2]

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**4.** **Figure 4a** shows two fossil leaves used to indicate changes in climate based on leaf shape. **Figure 4b** shows the correlation between mean annual temperature and leaf shape in modern leaves.


Fossil land plants may provide evidence of different climatic zones. The percentage of smooth-margined fossil leaf species can be used to estimate a mean temperature for fossil forests.

In general, forests in warmer climates have a higher percentage of smooth (entire) margined leaf species. Leaves in temperate forests often have jagged (toothed) margins, and tend to dominate in cooler climates.


**Figure 4a**

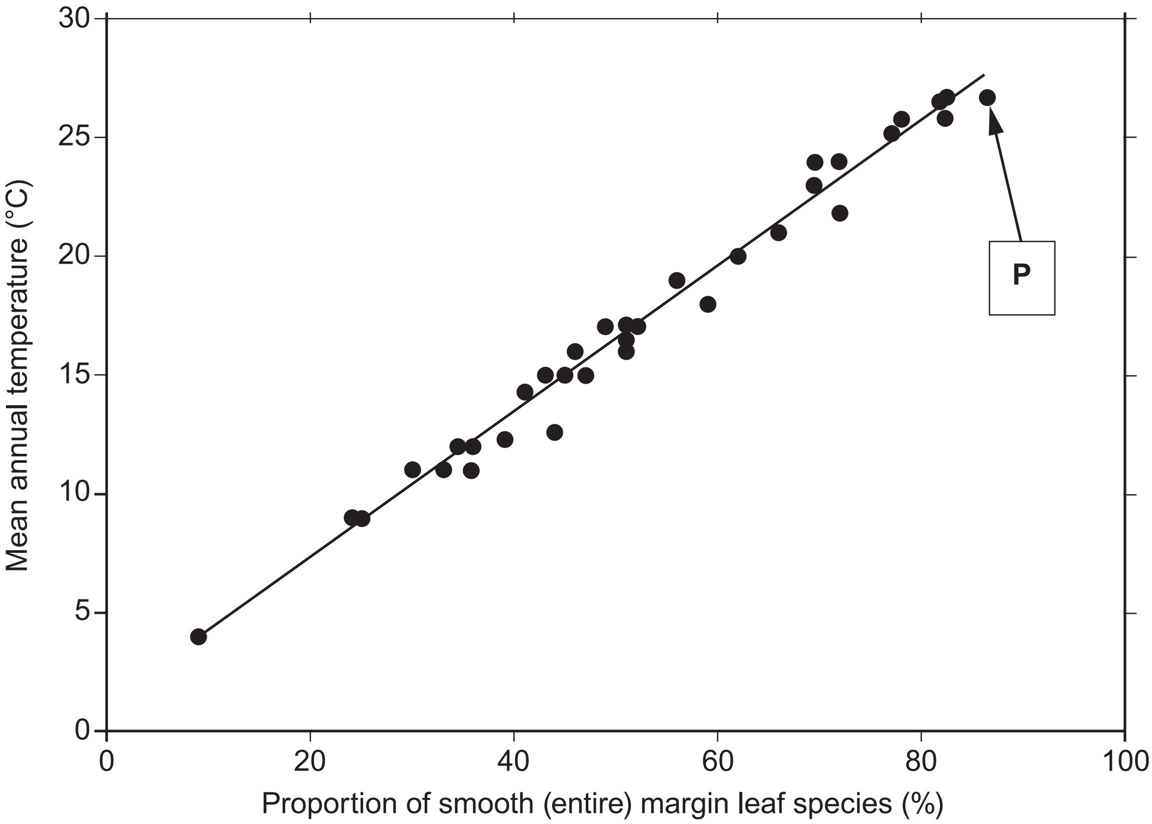


**Figure 4b**

Examiner only

*(a)* Refer to **Figure 4a**.

Describe **two** differences in the shapes of leaves **X** and **Y**. [2]

1. ..............................................................................................................................................

2. ..............................................................................................................................................

*(b)* Refer to **Figure 4b**.

(i) Describe the correlation in **Figure 4b**. [2]

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(ii) Identify which of the fossil leaves (**X** or **Y**) best represents the most common shape of leaf margin species at point **P** in **Figure 4b**. Explain your answer. [2]

*Leaf* (**X** *or* **Y**) ☐

*Explanation* ..............................................................................................................................

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Examiner only

*(c)* **Figure 4c** shows the estimated variation in mean annual temperature based on the outline shapes of fossil leaves during the last 60 million years. **Figure 4d** shows the variation in $^{18}O$:$^{16}O$ ratios measured in deep ocean sediments over the same period. (after Ruddiman: Earth's Climate, Past and Present).

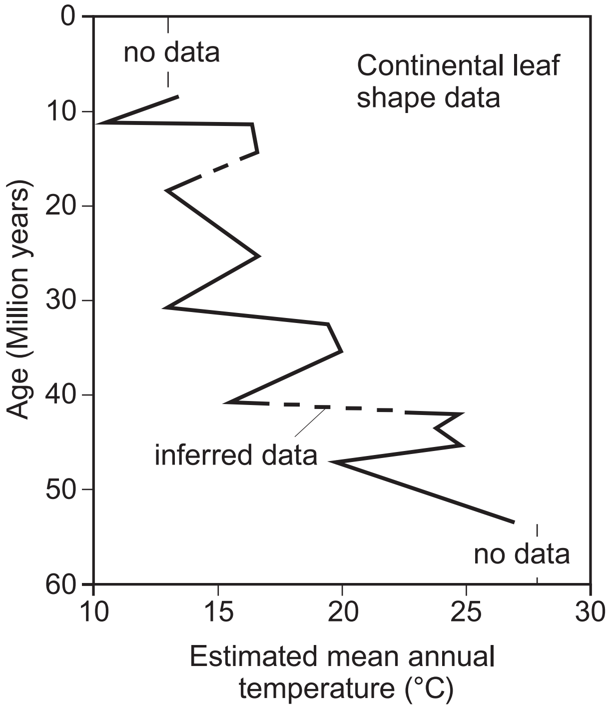


**Figure 4c**

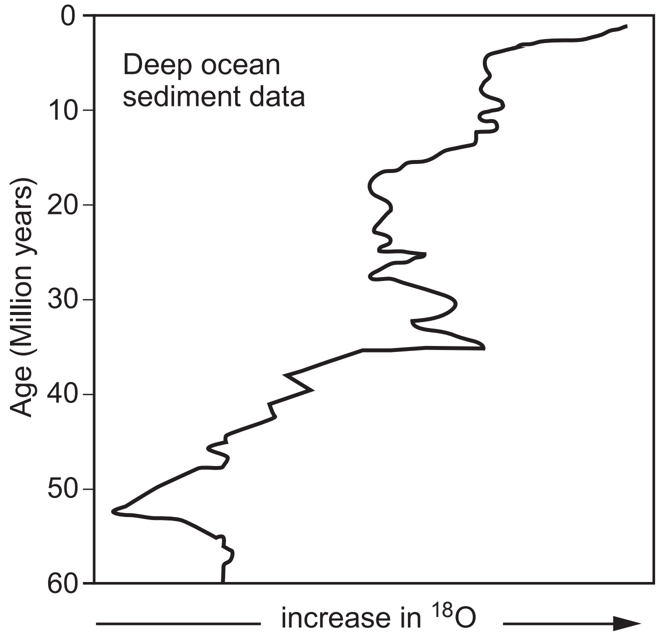


**Figure 4d**

(i) On **Figure 4c**, mark in a line of best fit for the data set. [1]

(ii) Describe the changes in the mean annual temperature during the last 60 million years based on leaf shape, in **Figure 4c**. [2]

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(iii) With reference to **Figure 4d**, explain the overall increase in $^{18}O$ recorded in deep ocean sediments during the last 60 million years. [3]

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Examiner only

*(d)* With reference to **Figures 4c** and **4d and your knowledge**, suggest why the continental temperature record, based on leaf shape, may be less reliable than the record obtained from deep ocean sediments. [3]

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Examiner only

## SECTION B

*Questions **5–8** relate to the **British Geological Survey 1:50 000 geological map** extract of **Whitehaven***

*Answer **all** questions in the spaces provided.*
*This section should take approximately 1 hour to complete.*

**5.** *(a)* Refer to boxes **X** and **Y** on the **geological map**.

(i) Calculate the **mean** angle of dip of the St Bees Sandstone (**SBS**) within **box X**. Show your working. [2]

Mean dip = .............................................................. degrees

(ii) Using an annotated diagram(s), describe the field measurements that were made at these localities so that the dip symbols could be plotted. [3]

(iii) State how the outcrop pattern in **box Y** on the **geological map** suggests that the St Bees Sandstone (**SBS**) is dipping at

- a low angle
- to the SW. [3]

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Examiner only

*(b)* **Figure 5** is a photograph of the cliff face at South Head (**grid reference – GR 950120**).

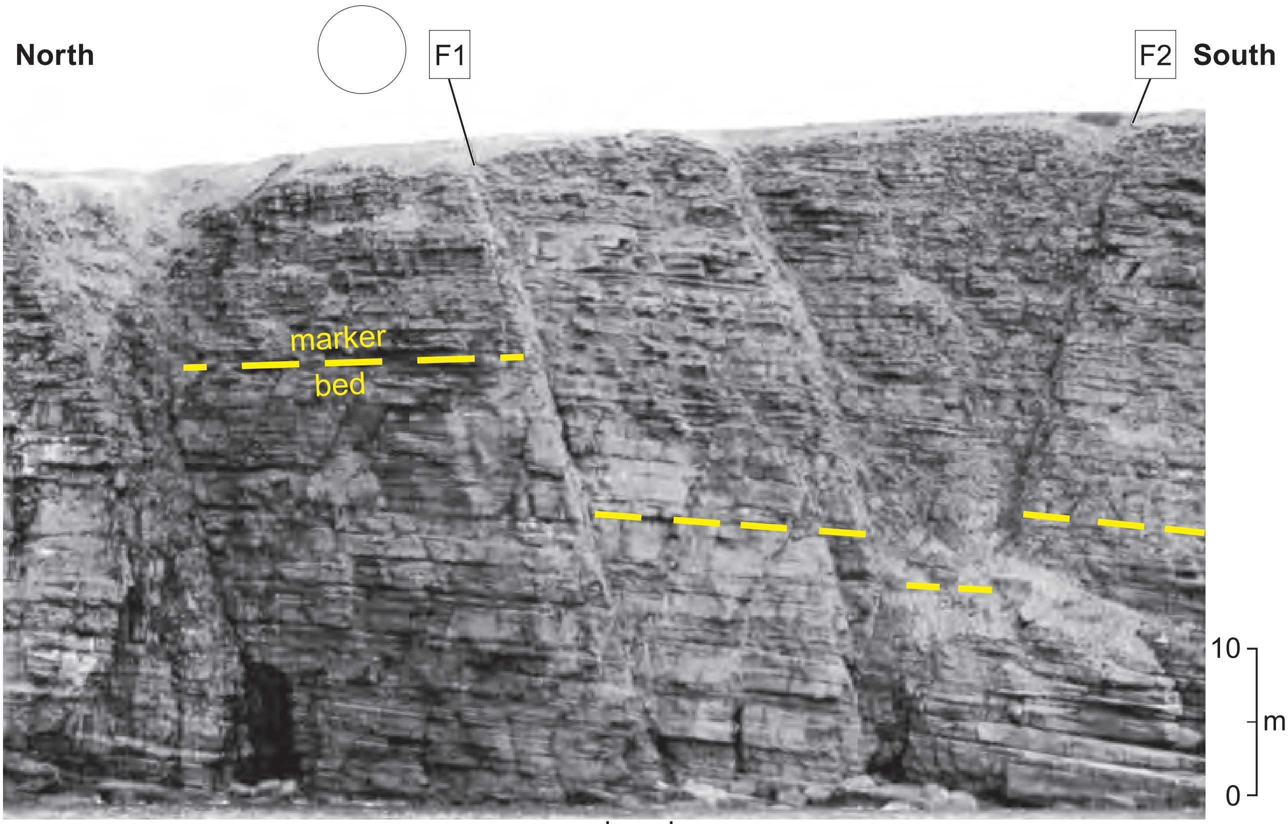


**Figure 5**

(i) Complete **Table 5** to describe the fault characteristics of the two faults (**F1** and **F2**) shown at South Head on **Figure 5**. [3]

| Fault characteristic | Fault **F1** | Fault **F2** |
|---|---|---|
| Apparent dip of fault (degrees) | • | |
| Throw (m) | • | 5 m |
| Fault type | Normal | • |

**Table 5**

Examiner only

(ii) Draw an arrow (⤡) in the blank circle on **Figure 5** to show the orientation of the principal stress component, **σ max** for fault **F1**. [1]

(iii) With reference to the **geological map, cross-section** and **Figure 5**, compare the faults at North Head (**grid square 9414**) with South Head (**Figure 5**) by stating **one** similarity and **one** difference in the orientation of the principal stress component, **σ min**. [2]

*Similarity* ...............................................................................................................

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*Difference* ...............................................................................................................

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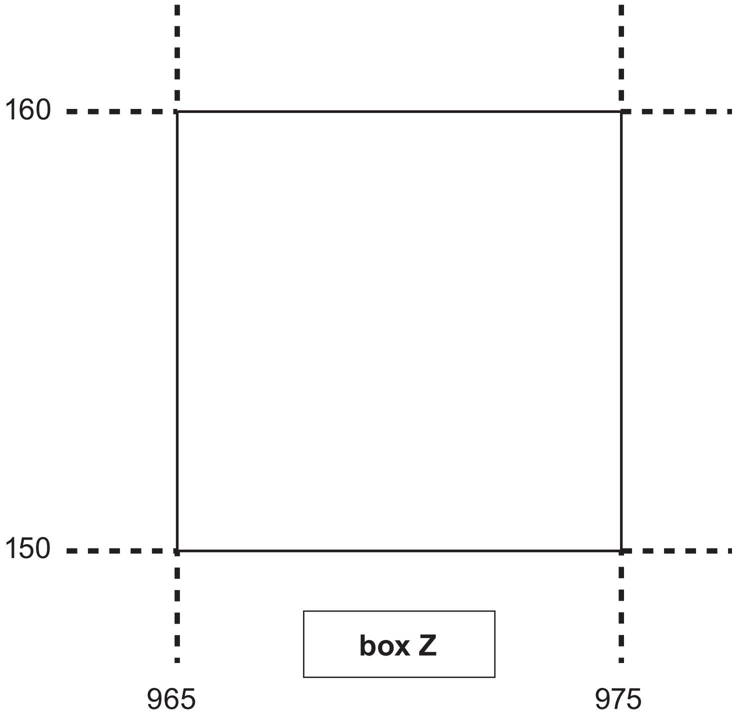
Examiner only

**6.** The **generalised geological column** indicates an unconformity at the base of the Permo-Triassic Brockram (**BK**).

*(a)* (i) In the blank grid square below, draw and label the map evidence for this unconformity from **box Z** on the **geological map**.

Carefully label on your map

- the **line of unconformity**
- the **relative age** of the strata (younger or older) that crop out on either side of the unconformity. [3]




(ii) With reference to the **generalised geological column** suggest the most probable reason for the variation in the width of outcrop of the St Bees Evaporite (**SBE**) in **box Z**. [1]

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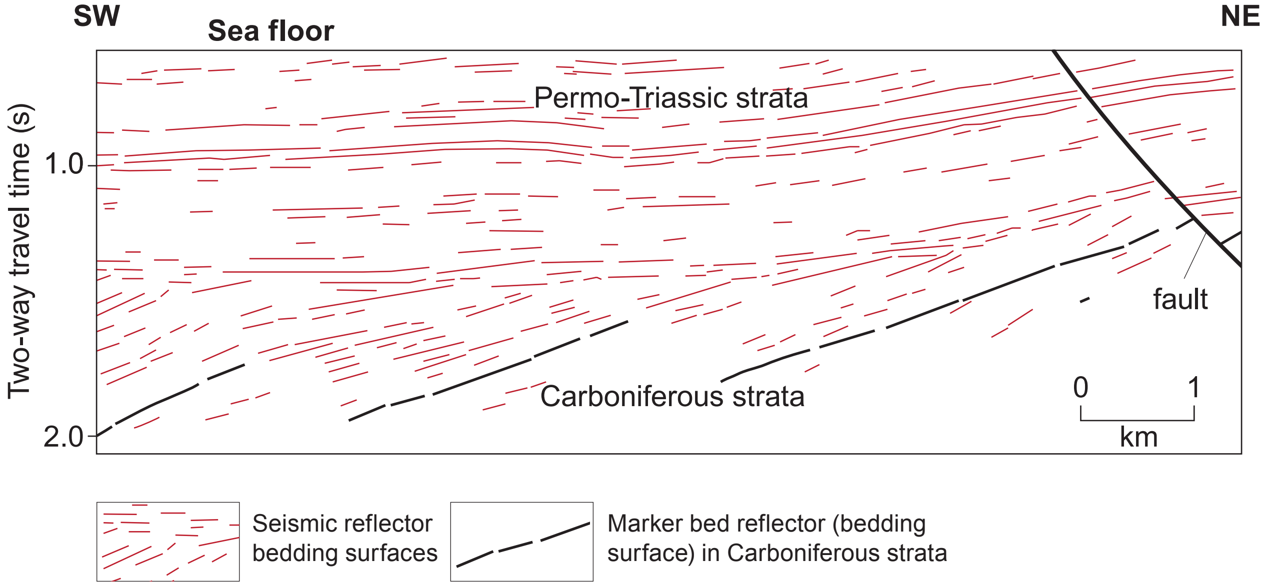
Examiner only

*(b)* **Figure 6** is an offshore seismic reflection section recorded to the west of the **geological map** in the Irish Sea.




Note: Although the horizontal scale is in kilometres, the vertical scale is two-way travel time (in seconds), not depth. Two-way travel time is the time taken for seismic waves to travel from the surface to a sub-surface rock boundary (a bedding plane, fault etc.) and back to the surface.

**Figure 6**

(i) Mark and label on **Figure 6** the extent of

1. the unconformity at the base of the Brockram (**BK**),
2. **two inclined** faults that are older than the unconformity. [4]

(ii) The mean seismic wave velocity through this section is 2.15 $km\,s^{-1}$ (kilometres per second). Calculate the **maximum** depth of the marker bed reflector in Carboniferous strata, on the seismic section. Show your working. [2]

Depth = .............................................. km

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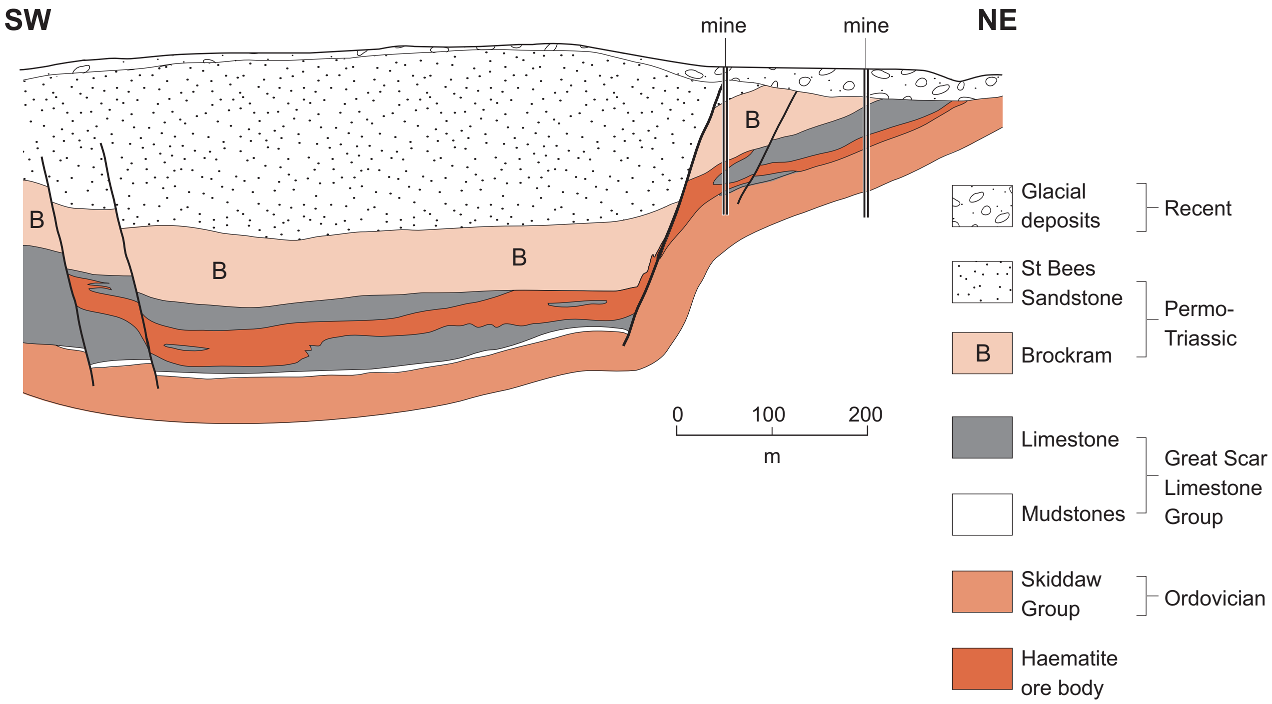
Examiner only

**7.** **Figure 7** shows a section through a typical haematite ore body seen on the **geological map**, (e.g. grid square **0011**).




**Haematite – Iron ore**

The formation of the haematite iron ore bodies is believed to be associated with

1. iron-rich mineralising fluids,
2. fluids percolating through fractures and permeable strata,
3. the replacement of limestone.

**Figure 7**

Using the **geological map** and **Figure 7**, evaluate the evidence that suggests the distribution of haematite ore bodies is controlled by rock type and structure. [4]

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**8.** **Figure 8a** shows the result of a survey to rule out areas of west Cumbria (including up to 5 km offshore) that are geologically **unsuitable** to host a radioactive waste disposal facility. **Table 8** shows the exclusion criteria used in the survey.

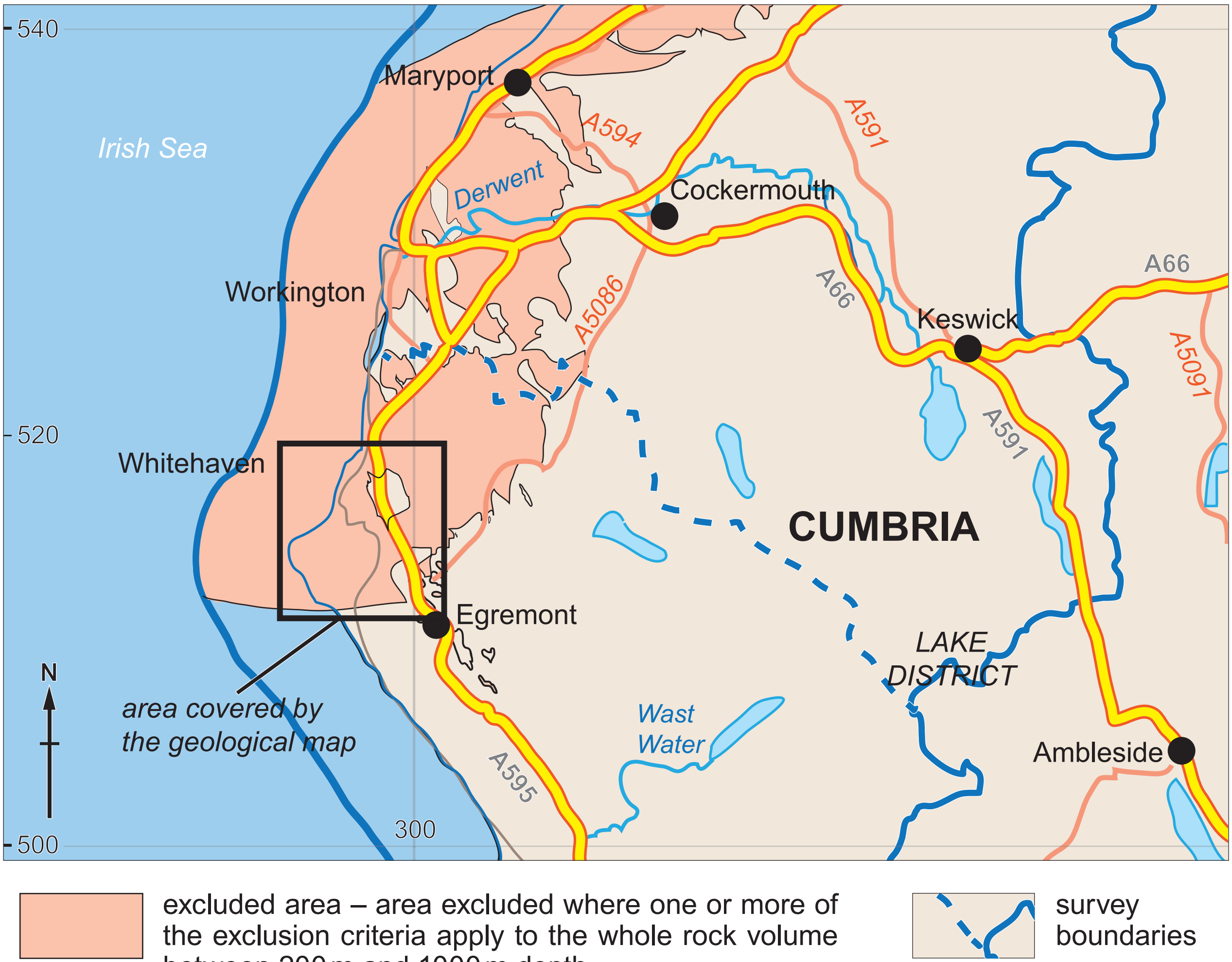


**Figure 8a**

| **Exclusion Criteria** |
|---|
| The survey criteria were based only on the need to **exclude** areas: |
| 1. where exploitable freshwater groundwater resources exist **below 200 m** deep; |
| 2. where one or more natural resources exist **below 200 m** deep (minerals, fossil fuels and alternative energy resources) that might be exploited by future generations. |

**Table 8**

Examiner only

**Figure 8b** is a sketch section across an area of west Cumbria and the Irish Sea to the north of the **geological map**, showing the principal Sherwood Sandstone Group aquifer (which includes the St Bees Sandstone - **SBS**).

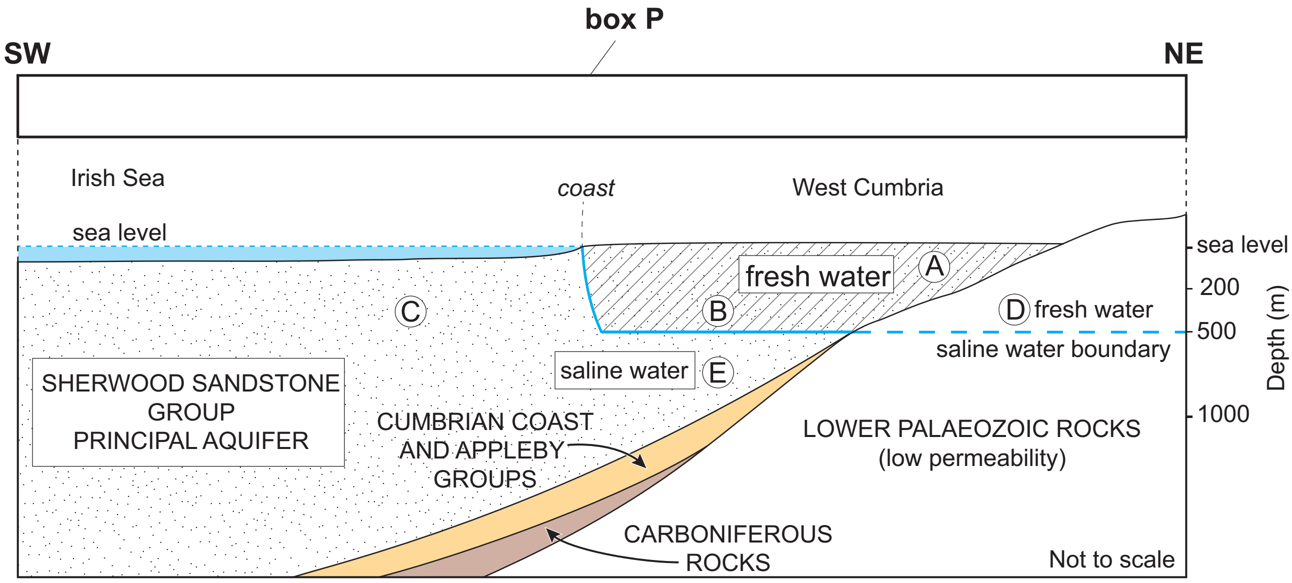


**Figure 8b**

*(a)* Refer to **Figure 8b** and the groundwater resource exclusion criterion (**criterion 1** in **Table 8**).

(i) State which **one** of the five locations (**A–E**) would qualify as being **unsuitable** as a host site for a radioactive waste facility, according to the groundwater resource exclusion criterion (**1**) **alone**. Explain your answer. [2]

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(ii) Shade in **box P** (**Figure 8b**) to show the extent of the area below which it is geologically **unsuitable** to dispose of radioactive waste according to the groundwater resource exclusion criterion (**1**) **alone**. [2]

Examiner only

*(b)* Using the **geological map** and **cross-section** and the **previous data**, explain why large parts of the area covered by the **geological map** were considered to be geologically unsuitable for radioactive waste disposal as defined by the exclusion criteria in **Table 8**. [4]

**Exclusion Criteria**

The survey criteria were based only on the need to **exclude** areas:

1. where exploitable freshwater groundwater resources exist **below 200 m** deep;
2. where one or more natural resources exist **below 200 m** deep (minerals, fossil fuels and alternative energy resources) that might be exploited by future generations.

**Table 8**

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*(c)* Suggest what other **geological** factors might also need to be considered when determining the suitability of a potential site for a radioactive waste facility in western Cumbria. [4]

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**END OF PAPER**

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Figures 1a, 1b, 1c and 1d Source: After Rudwick – “Living and Fossil Brachiopods” – Sedgwick Museum

Figures 2b and 2c Source: Adapted from http://www.geodz.com/deu/d/images/1859_lagenintrusion.png

Figure 2d Source: www.elbrownpetrology.com/photos.html

Figure 4a Source: http://nature.nps.gov/geology/nationalfossilday/climate_change_past.cfm,
http://geology.com/articles/green-river-fossils/plant-fossils.shtml

Figure 4b Source: http://droyer.web.wesleyan.edu/research.htm#margins

Figure 5 Source: BGS: Geology of the west Cumbria district (Plate 3)

Figures 6 and 7 Source: BGS: Geology of the west Cumbria district

Figures 8a and 8b Source: BGS report. (CR/10/072)-Managing radioactive waste safely: Initial geological unsuitability screening of west Cumbria

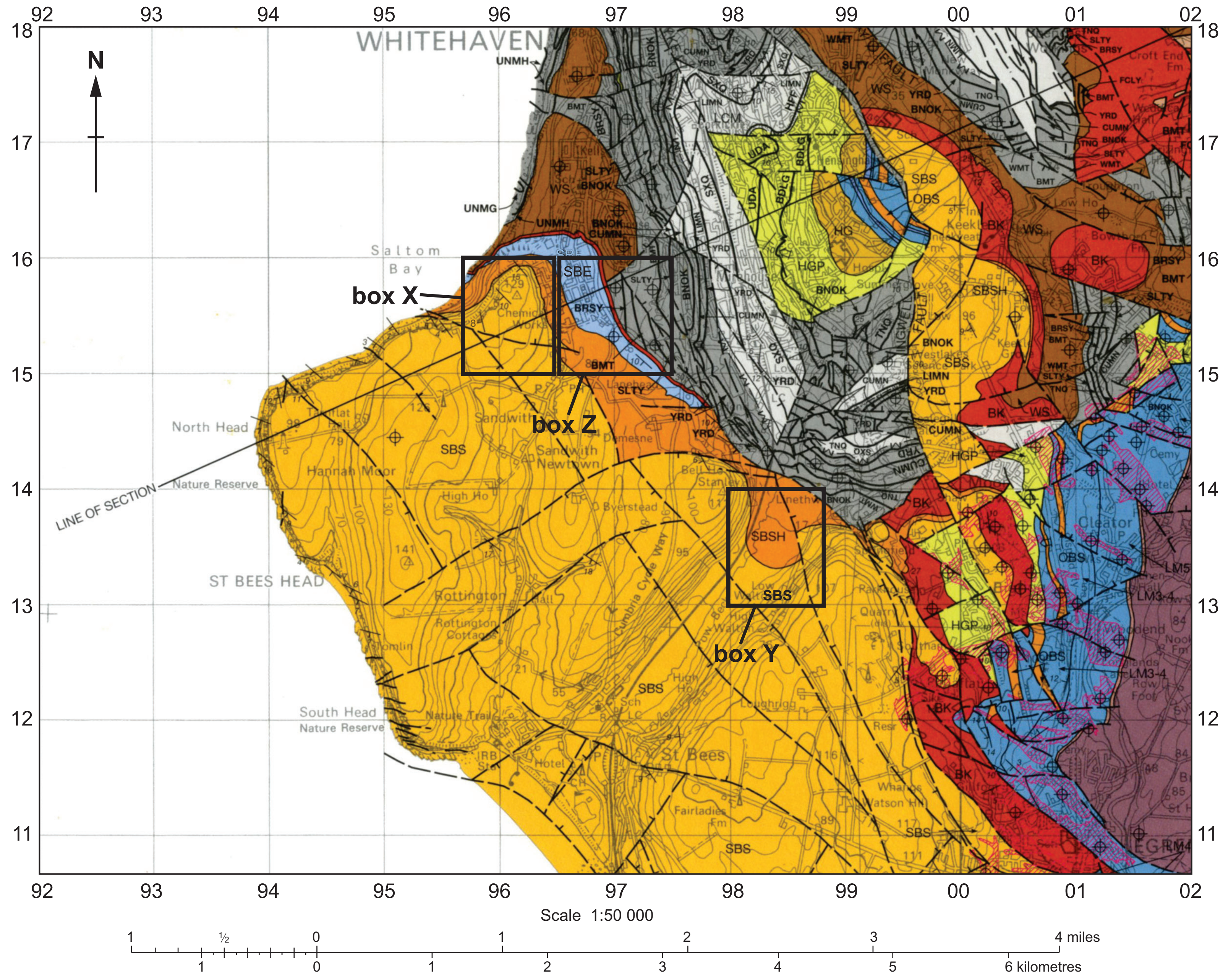
**GCE A level**

1214/01-A

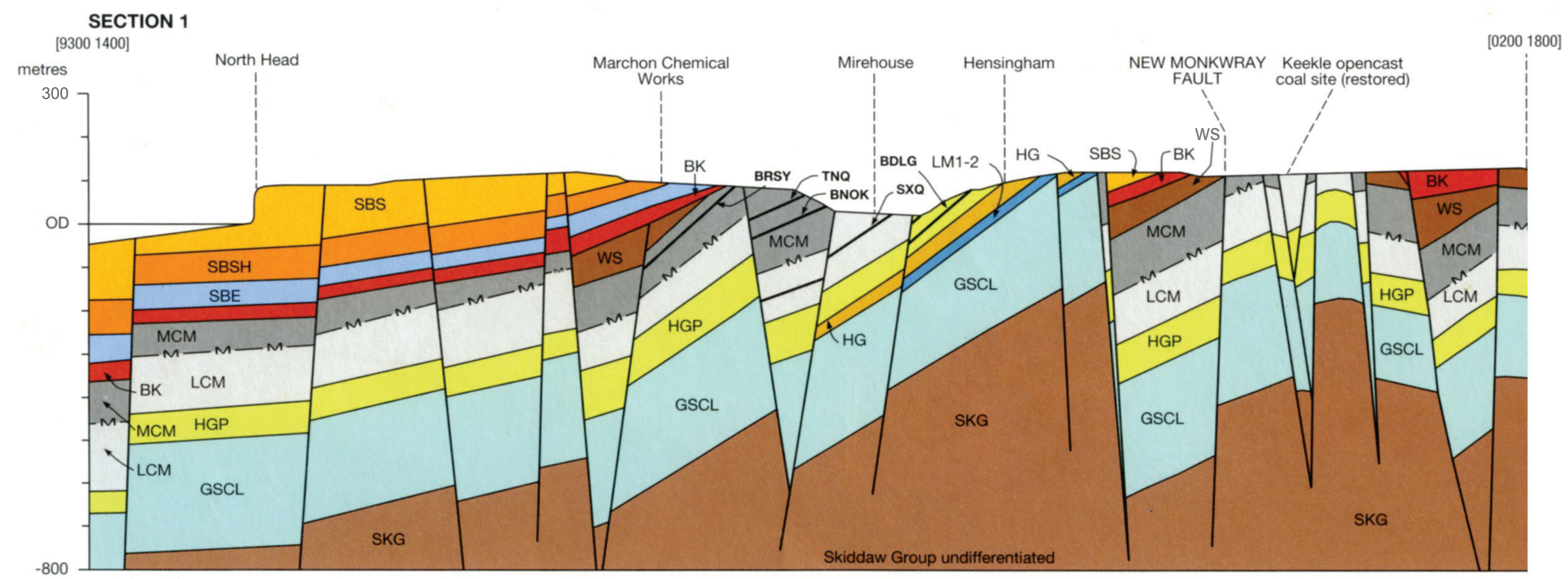
**GEOLOGY – GL4**
**Interpreting The Geological Record**

A.M. MONDAY, 2 June 2014

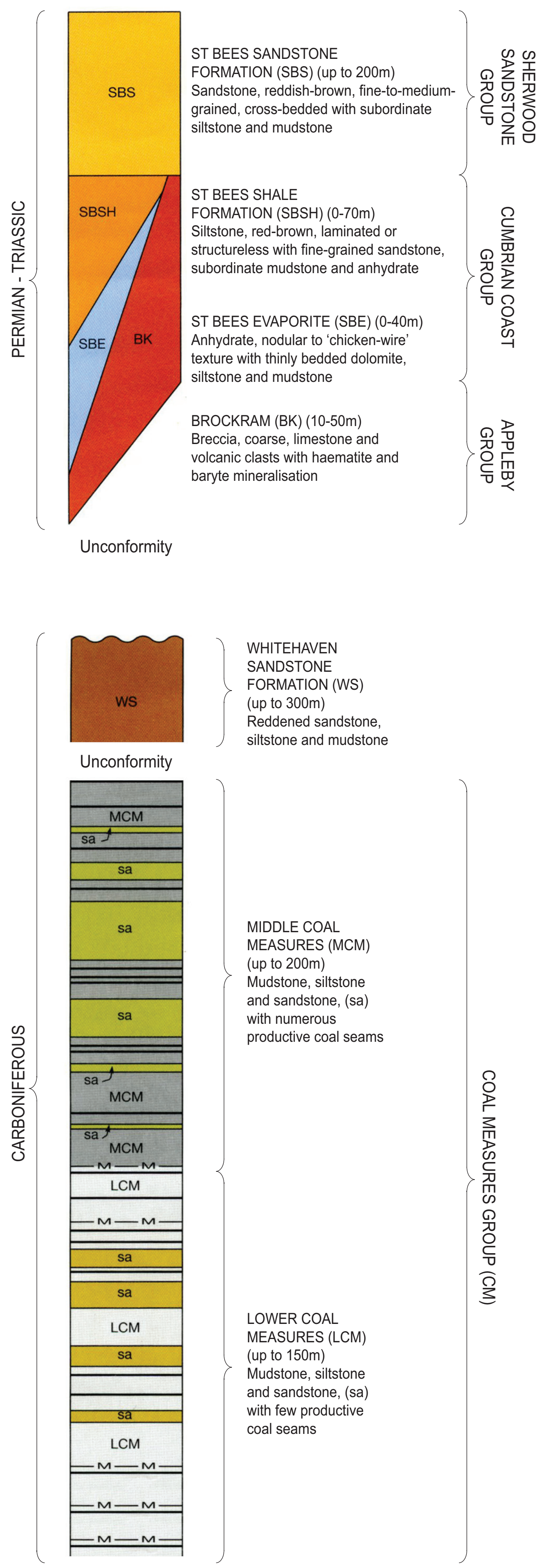
# WJEC 1214/01-A ADVANCED GEOLOGY GL4 JUNE 2014
## Extract from Whitehaven Sheet 28 (Bedrock) 1:50 000 (1 cm to 500 m)

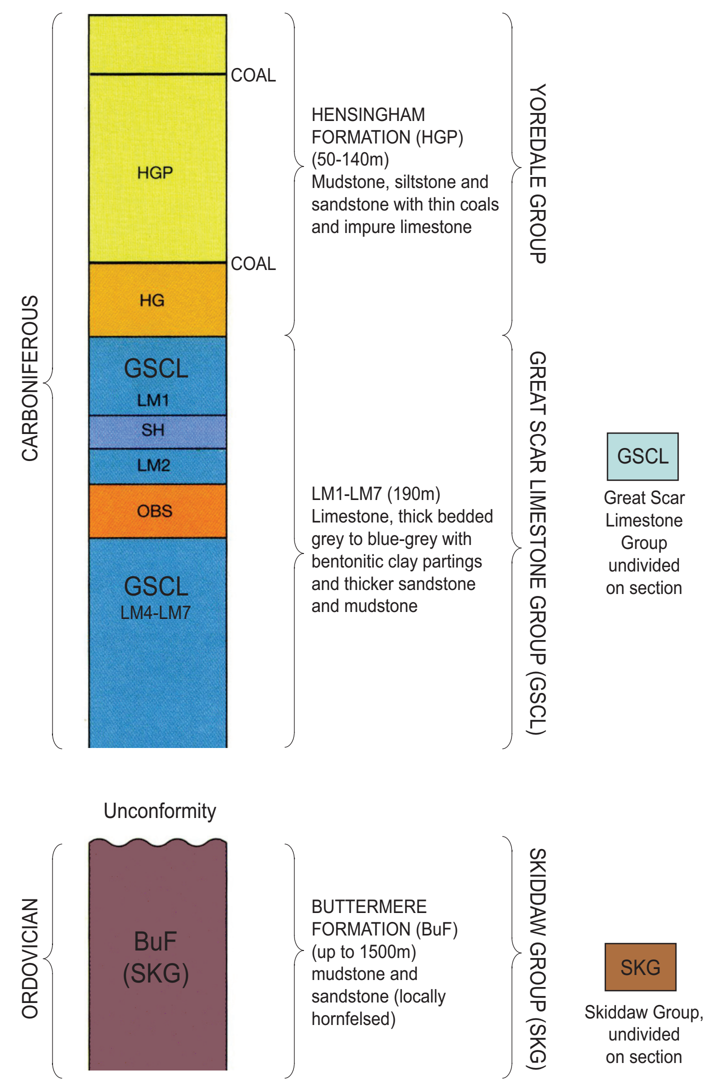



## CROSS SECTION SHOWING THE GENERAL RELATIONS OF ROCKS ALONG LINE OF SECTION




# GENERALISED GEOLOGICAL COLUMN
## Bedrock (Solid) Geology – Not drawn to scale




### KEY to SYMBOLS

- Geological boundary, Bedrock
- Fault at rockhead, crossmark on downthrow side
- YRD Coal
- Pb Mineral veins, **Pb** Lead, **Fe** Iron (Haematite)
- Horizontal strata
- 5 Inclined strata, dip in degrees
- Pit or mineshaft, abandoned
- Adit or mine mouth, abondoned with orientation showing direction of entry
- Area of Haematite mining